(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 032 108 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
30.08.2000 Bulletin 2000/35

(51) Int Cl.7: H02J 7/00

(21) Application number: 00103902.3

(22) Date of filing: 24.02.2000

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 26.02.1999 JP 4981899
31.03.1999 JP 9162499

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(54) Battery pack

(57) The battery pack houses a protection circuit (3) along with a rechargeable cell (2) in a case (1). The protection circuit is provided with switching devices (7) to control current flow in the rechargeable cell, and a control circuit to control the switching devices. The protection circuit is molded in a single package with insulating material to make a one-package unit. The one-package unit is retained in a holding space in an insulating holder (6). The one-package unit, insulating holder, and rechargeable cell are held in the case.

FIG. 2

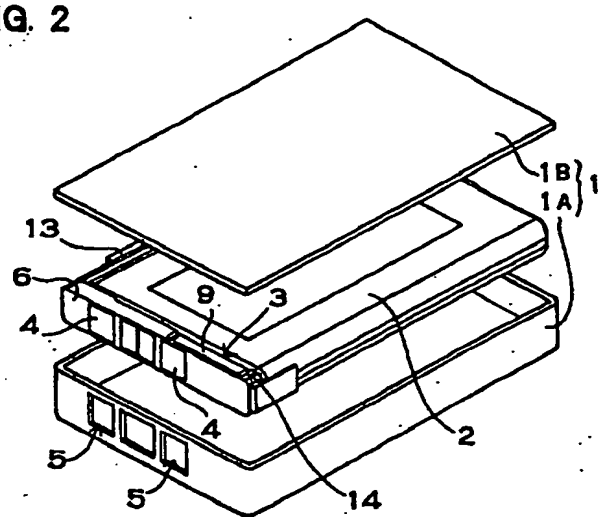

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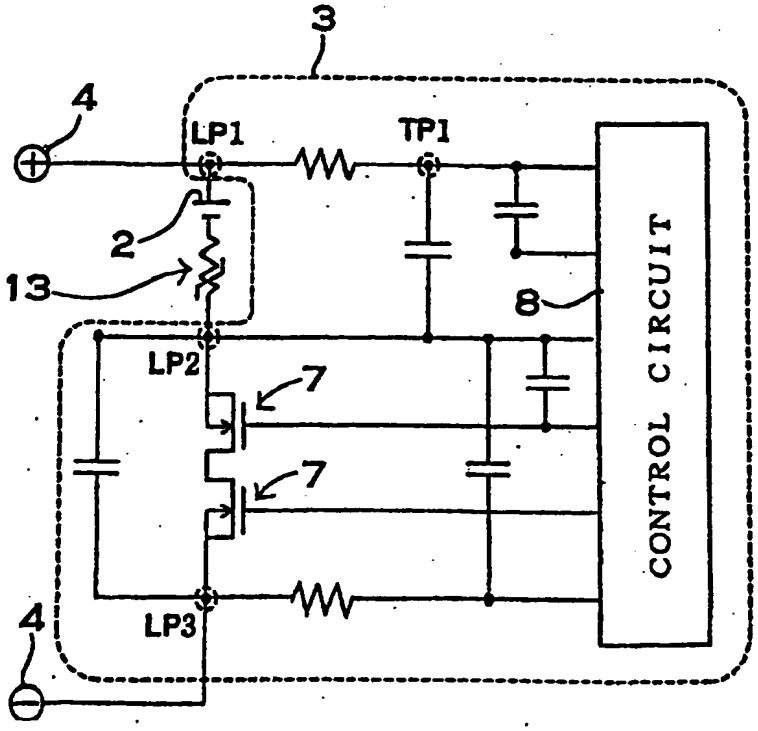
FIG. 3



Description

[0001] This application is based on applications No. 11-49818 filed in Japan on Feb. 26, 1999 and No. 11-91624 filed on Mar. 31, 1999, the content of which incorporated hereinto by reference.

Background of the Invention

[0002] This invention relates to a battery pack containing a rechargeable cell and a protection circuit.

[0003] A battery pack containing a protection circuit has been developed (Japanese Non-examined Patent Publication HEI 8-329913, 1996). As shown in Fig. 1, the battery pack disclosed in this patent application contains a prismatic battery 1016, which is a lithium ion rechargeable cell, and a protection circuit 103. The protection circuit 103 detects battery current and voltage and controls the system to avoid use of the battery under abnormal conditions. The protection circuit 103 prevents battery over-charge and over-discharge, or controls the system to avoid extremely large current flow through the battery. To control current flow through the battery, the protection circuit 103 utilizes a switching device such as a field effect transistor (FET) connected in series with the battery. The switching device is controlled by a control circuit. The control circuit detects battery voltage or current and controls the switching device on or off. When the control circuit turns the switching device off, current flow through the battery is cut-off.

[0004] The battery pack shown in Fig. 1 has a surface mounted protection circuit 103 on a printed circuit board 1017 disposed between the prismatic battery 1016 and a case 101. The printed circuit board 1017 has a large number of electronic parts attached to implement the switching device and the control circuit to turn that switching device on and off. Further, insulating paper 1018 is disposed on both sides of the printed circuit board 1017 to insulate the electronic parts attached to the printed circuit board 1017.

[0005] Since the switching device and control circuit are mounted on the surface of the printed circuit board of the battery pack shown in Fig. 1, the protection circuit can fail to function properly due to electrolyte leaking from the battery. This is because electrolyte can cause corrosion of metal regions attached to the printed circuit board surface, or cause short circuits between conducting regions due to migration or dendrite growth. Since the protection circuit protects the battery against use in abnormal circumstances, it is critical for the protection circuit to function properly in the abnormal situation when electrolyte leaks from the battery. Therefore, it is important for the protection circuit to reliably protect the battery even when electrolyte leaks from the battery.

[0006] In addition, moisture ingress can occur during battery use. Similar to electrolyte leakage, moisture ingress can adversely affect protection circuit electronic parts, or corrode metal regions to interfere with proper functioning of the protection circuit. This drawback can be eliminated by making the battery pack case a completely hermetic structure. However, a completely hermetic structure cannot be made because of the requirement to expose terminals such as electrode terminals outside the battery pack case. Therefore, how to have a proper functioning protection circuit when moisture ingress occurs is extremely important.

[0007] Further, it is extremely difficult to make a battery pack, which has a switching device and protection circuit surface mounted on a printed circuit board, with a structure sufficiently resistant to vibration. This is because when the battery pack is vibrated, switching device and protection circuit electronic parts connected to the printed circuit board are also vibrated. Since electronic parts are attached to conducting layers on the surface of the printed circuit board, there is also the drawback that vibration can easily delaminate conducting layers. Consequently, it is possible for protection circuit electronic parts surface mounted to a printed circuit board to become damaged or disconnected in a battery pack which is assembled by a method which imparts vibration such as ultra-sonic welding of the case.

[0008] Still further, because prior art battery packs have large protection circuits, restrictions are placed on the location of parts within the case. For this reason, parts cannot always be located in ideal locations. For example, it may not be possible to place the protection circuit at its closest position to connecting parts. Consequently, drawbacks such as long protection circuit connecting leads may also result.

[0009] The present invention was developed to eliminate these types of drawbacks observed in prior art battery packs. Thus it is an important object of the present invention to provide a battery pack which drastically reduces protection circuit malfunction generated by battery electrolyte leakage and moisture ingress, and which has a structure of superior resistance to vibration.

[0010] Another important object of the present invention is to provide a battery pack in which the protection circuit can be made extremely compact and can be freely located within a case with a water resistant, vibration resistant, and insulating structure.

[0011] The above and further objects and features of the invention will more fully be apparent from the following detailed description with accompanying drawings.

Summary of the Invention

[0012] The battery pack of the present invention has a case containing a rechargeable cell along with a protection circuit provided with a switching device, which is connected in series with the rechargeable cell and controls current flowing through the battery, and a control circuit, which detects battery voltage or current or both and controls the switching device. The protection circuit, provided with a switching device and a control circuit, is molded with insulating material into a single package as

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mounted on the surface of substrate material such as glass epoxy resin or ceramic. That surface is then covered with insulating resin 21 to encase the electronic parts in the insulating resin 21. In Fig. 6, the upper surface of the insulating substrate 9A is provided with surface electrodes 22.

[0046] Lead material 10 is connected to surface electrodes 22 on the insulating substrate 9A, and an insulating surface layer 9B is laminated to the upper surface of the insulating substrate 9A without creating gaps. In the case when the insulating surface layer 9B is formed from plastic, lead material 10 can be connected to the insulating substrate 9A, and the insulating substrate 9A can be inserted in a plastic mold to fix the unit. The one-package unit 9 has the protection circuit 3 molded in a manner covering it above and below with insulating material, and embedding and fixing on end of the lead material 10 within the package. The insulating substrate 9A and the insulating surface layer 9B of the one-package unit 9 may be the same insulating material or different insulating material.

[0047] The one-package unit 9 shown in Fig. 4 is also provided with a test-point hole 11 in its insulating surface layer 9B. The test-point hole 11 is opened at a position allowing the test-point 12 on the protection circuit 3 attached to the upper surface of the insulating substrate 9A to be contacted. During test of the protection circuit 3, a connecting pin is inserted into the test-point hole 11 to contact the test-point 12. Normally the test-point hole 11 is sealed closed by a removable seal or filler material.

[0048] As shown in Figs. 7 and 8, the one-package unit can also be connected to a printed circuit board 719, and lead material 710 can be connected. Fig. 9 shows a bottom view of a one-package unit 79 for mounting on a printed circuit board 719. The one-package unit 79 shown in Fig. 9 has an overall rectangular shape and has surface electrodes disposed in the four corners of the bottom surface. The corner region surface electrodes may be disposed on two sides, as shown in Fig. 9, or they may be disposed on one side (not illustrated). This type of one-package unit 79 has the feature that proper connection of the surface electrodes to the printed circuit board 719 can be confirmed with the one-package unit 79 solder attached to the printed circuit board 719. Further, as shown in Fig. 9, cut-outs 723 are provided on the edge sides of the surface electrodes, and these cut-outs 723 allow even more precise confirmation of the connection between the surface electrodes and the printed circuit board 719.

[0049] In the one-package unit 79 shown in Fig. 9, surface electrodes B+ and B-, which connect with the rechargeable cell positive and negative sides, are disposed at opposite ends. Since the one-package unit 79 can widely separate the B+ and B- surface electrodes, the battery pack has the characteristic that positive to negative battery short circuits can be effectively prevented. In the one-package unit 79 of Fig. 9, the B+ and B- surface electrodes are disposed in the upper corners, and the B- surface electrode and the V- surface electrode, which connects to a battery pack electrode terminal, are disposed on the left side corners. In a one-package unit 79 with this configuration, the B- surface electrode and the V- surface electrode can be connected with minimum wire length to reduce resistance between those electrodes.

[0050] Further, the one-package unit 79 shown in Fig. 9 has two test-point surface electrodes T1 and T2 disposed on the surface electrode side upper edge. Surface electrode T1, which is a test-point that connects to surface electrode B+ via a resistor, is disposed near the B+ surface electrode, and surface electrode T2, which is a test-point that connects to surface electrode V- via a resistor, is disposed near the B- surface electrode. This configuration of one-package unit 79 can reduce protection circuit malfunction when moisture has entered the battery pack. This is because short circuit current through surface electrodes B+, B-, and V- can be prevented via the test-point surface electrodes T1 and T2.

[0051] As shown in the plan view of Fig. 8, the one-package unit 79 is solder attached to the surface of the printed circuit board 719. For example, the one-package unit 79 is re-flow soldered for connection to the printed circuit board 719. Conducting film 724 is fixed to one side of the printed circuit board 719. Surface electrodes of the one-package unit 79 are connected to the printed circuit board 719 conducting film 724, and lead material 710 is also solder connected to the conducting film 724. The printed circuit board 719 structure with a one-package unit 79 and lead material 710 connected has the characteristic that lead material 710 can be joined to the one-package unit 79 with simple equipment.

[0052] The one-package unit 9 housing the protection circuit 3 is disposed within the case of the battery pack by means of the insulating holder 6. The one-package unit 9 is disposed inside the case via the insulating holder 6 in the configuration shown in Fig. 4 with embedded lead material 10, or in the configuration shown in Fig. 7 with one-package unit 79 and lead material 710 attachment to the printed circuit board 719. As shown in Fig. 10, the insulating holder 6 is a formed plastic piece provided with space 14 on its inside surface for holding a one-package unit 9 with no printed circuit board, or for holding a one-package unit attached to a printed circuit board. Electrode terminals 4 are embedded in the surface of the insulating holder 6.

[0053] In the insulating holder 6 shown in the figures, the one-package unit holding space 14 is established on the side facing the rechargeable cell 2. The holding space 14 opening is made to a size which retains the one-package unit 9 with almost no gaps. For the insulating holder 6 to retain the one-package unit 9 in a specified position of the holding space 14, the one-package unit 9 and holding space 14 are made in a snap-together or pressure-fit configuration, or the printed circuit board with a one-package unit attached and the holding space

14 are made in a snap-together configuration.

[0054] The battery pack shown in Fig. 2 has a rechargeable cell 2, which is a thin outline battery, contained in the case 1. The insulating holder 6 is disposed at one end of the rechargeable cell 2, and the one-package unit 9 is disposed between the insulating holder 6 and the rechargeable cell 2. The insulating holder 6 has a width approximately equal to the width of the rechargeable cell 2. The insulating holder 6 has electrode terminals 4 fixed to its front side and is provided with holding space 14 on its inside surface to contain the one-package unit with a configuration shown in Fig. 4 or Fig. 7. The insulating holder 6 is provided with side walls on both sides of its inside surface formed as a single piece with the insulating holder 6. One part of these side walls has cut-outs which establish the holding space 14 for housing the one-package unit 9.

[0055] However, the battery pack of the present invention may also be configured with the holding space for housing the one-package unit established inside the side walls provided on the insulating holder. In this type of insulating holder, the printed circuit board to which the one-package unit is attached closes off the holding space. Namely, the structure can be such that the one-package unit is inserted inside the holding space, and the printed circuit board closes the holding space opening.

[0056] The insulating holder 6 shown in the figures utilizes space adjacent to the projecting rechargeable cell 2 electrode as the holding space 14, and the one-package unit 9 is contained in that space. The one-package unit 9 contained here has lead material 10, which project in the lengthwise direction from the ends of the rectangular shaped one-package unit 9, and connect to projecting rechargeable cell 2 electrodes. The rectangular shaped one-package unit 9 resides in the insulating holder 6 holding space 14 parallel to the end of the long narrow rechargeable cell 2. This configuration allows lead material 10 connected to the one-package unit 9 to connect with projecting rechargeable cell 2 electrodes over a short distance. This configuration allows the one-package unit 9 or the printed circuit board with the one-package unit attached to be reliably retained in a fixed position. In addition, since space adjacent to the projecting rechargeable cell 2 electrode can be efficiently used to house the one-package unit 9, the battery pack has the feature that it can house the protection circuit 3 and its external size can be reduced.

[0057] In the battery packs shown in Figs. 11 through 14, leads 1115, 1315 are disposed on the surface of the thin outline battery. In these figures, the one-package unit 119, 139 is fixed to a printed circuit board 1119, 1319 and mounted in the insulating holder 116, 136. Leads 1115, 1315 connecting the rechargeable cell 112, 132 and the one-package unit 119, 139 are located on the laterally extending wide surface 112A, 132A of the rechargeable cell 112, 132, and are disposed along the edge of that surface. One end of a lead 1115,1315 is connected to the rechargeable cell 112, 132, and the other end is connected to the one-package unit 119, 139 or to the printed circuit board 1119, 1319. The lead 1115, 1315 is arranged in this position and retained within the case (not illustrated). This configuration of battery pack can house a lead 1115, 1315, and efficiently use the volume inside the case. This is because the laterally wide surface of a thin prismatic battery expands at the center when internal pressure becomes great. This creates a gap between the case and the rechargeable cell 112, 132, but a lead is disposed in this gap. The wide central portion of a rechargeable cell 112, 132 with high internal pressure expands, but the side edges do not expand. Since the lead 1115, 1315 is disposed along a side edge which does not expand, the case does not have to be made larger to accommodate the lead 1115, 1315. In these figures, 114, 154 are the electrode terminals, 1110, 1510 is the lead material, and 1114, 1514 is the holding space.

[0058] As shown in the circuit diagram of Fig. 3, the three pieces of lead material 10 connected to the one-package unit 9 connect to the positive side battery electrode terminal 4, a PTC device 13, and the negative side battery electrode terminal 4. The PTC device 13 is connected in series with the battery and is disposed in contact with the battery surface. PTC device 13 resistance rapidly increases when battery temperature climbs to a prescribed temperature. Therefore, when battery temperature becomes abnormally high, current flow becomes negligible and is effectively cut-off. Since this battery pack is doubly protected by both a PCT device 13 and a protection circuit 3, reliability is made even greater. A battery pack with a doubly protected battery can also contain a fuse instead of a PCT device. Further, a battery pack can contain a fuse, a PCT device, and a protection circuit. However, the battery pack of the present invention does not necessarily have to contain a device such as a PCT or a fuse in addition to the protection circuit.

[0059] A battery pack of this structure is assembled by the following steps.

(1) The one-package unit 9 containing the protection circuit 3 is set in the insulating holder 6 holding space 14.

(2) one-package unit 9 lead material 10 is connected to insulating holder 6 electrode terminals 4 by a method such as spot welding.

(3) The insulating holder 6 is mounted in a fixed position on the rechargeable cell 2, and the remaining one-package unit 9 lead material 10 is connected to the rechargeable cell 2 and the PCT device 13 by a method such as spot welding.

(4) The other PCT device 13 lead material is connected to the rechargeable cell 2 via a lead 15.

(5) The mutually connected rechargeable cell 2, insulating holder 6, and PCT device 13 are inserted into a fixed position in the lower case 1A.

(6) The upper case 1B is ultra-sonically weld attached or joined by bonding to the open region of the lower case 1A to connect the upper and lower parts of the case 1.

[0060] Finally, as shown in Fig. 15, an electrode terminal holder 1525 may also be connected to the electrode terminals 154 of the insulating holder 156. In this battery pack, the electrode terminal holder 1525 connected to the electrode terminals 154 is changed among various formats to correspond to the type of electrical equipment the battery pack will be housed in. In this manner, a battery pack provided with an electrode terminal holder 1525 uses the same shaped insulating holder 156. Specifically, the connected rechargeable cell 152, one-package unit 159, and insulating holder 156 are treated as a single unit and only the electrode terminal holder 1525 is made to adapt to a plurality of types of electrical equipment. Thus, this battery pack has the feature that it can be produced in quantity extremely efficiently. This battery pack is assembled by attaching the electrode terminal holder 1525 to the insulating holder 156 electrode terminals 154 and then installing them in a fixed position in the case, or by installing the rechargeable cell, one-package unit, and insulating holder in a fixed position in the case and then connecting the electrode terminal holder to the insulating holder electrode terminals. In Fig. 15, 1513 is the PCT device, 1514 is the holding space, and 1515 is a lead.

[0061] In the battery pack embodiment described above, the rechargeable cell, one-package unit, and insulating holder are installed in a case, which is a formed plastic piece. A battery pack with a heat-shrink film case is assembled by covering the connected structure of one-package unit, insulating holder, and rechargeable cell with heat-shrink film. This battery pack can also be configured, for example, by providing electrode terminals on the insulating holder, or by extending leads outside without providing electrode terminals on the case, and joining the ends of the leads to connectors housing the electrode terminals.

[0062] As this invention may be embodied in several forms without departing from the spirit of essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, since the scope of the invention is defined by the appended claims rather than by the description preceding them, and all changes that fall within the meets and bounds of the claims or equivalence of such meets and bounds thereof are therefore intended to be embraced by the claims.

Claims

1. A battery pack comprising:

   (1) a rechargeable cell;
   (2) a rechargeable cell protection circuit having;
   (a) a switching device [7] connected in series with the rechargeable cell [2] to control current flow through the battery;
   (b) a control circuit [8] to detect battery voltage or battery current or both, and control the switching device [7];

   (3) a case to house the protection circuit and the rechargeable cell;
   (4) a one-package unit [9], which is the protection circuit [3], provided with the switching device [7] and the control circuit [8], molded as a single package with insulating material; and
   (5) an insulating holder [6], which houses the one-package unit [9] in a holding space [14], and retains the one-package unit [9] in a specified position inside the case.

2. A battery pack as recited in claim 1 wherein the rechargeable cell [2] is a prismatic lithium ion rechargeable cell.

3. A battery pack as recited in claim 1 or 2 wherein the case [1] containing the rechargeable cell [2] the one-package unit [9], and the insulating holder [6] is a ultrasonic-weld attached plastic case.

4. A battery pack as recited in any of the claims 1 to 3 wherein the one-package unit [9] is the protection circuit [3] molded in an epoxy resin.

5. A battery pack as recited in claim 4 wherein the epoxy resin, which molds the protection circuit [3], is a resin which hardens at room temperature by mixing two liquids together without heating.

6. A battery pack as recited in any of the claims 1 to 3 wherein the insulating material which molds the protection circuit is a silicone resin.

7. A battery pack as recited in claim 1 or 2 wherein the one-package unit [9] is a laminated package of insulating material on both the upper and lower surfaces containing the protection circuit [3].

8. A battery pack as recited in claim 7 wherein the one-package unit [9] is an insulating substrate [9A] bottom layer laminated with an upper surface insulating layer [9B] tightly sealing the unit without gaps.

9. A battery pack as recited in claim 8 wherein FETs, a control circuit IC, resistors, and capacitors, which implement the protection circuit are mounted on the bottom layer insulating substrate [9A].

10. A battery pack as recited in claim 8 wherein lead material is connected to the bottom layer insulating substrate [9A].

11. A battery pack as recited in claim 9 wherein the bottom layer insulating substrate is a glass epoxy resin and an insulating resin [21] covers its surface.

12. A battery pack as recited in claim 9 wherein the bottom layer insulating substrate is a ceramic material and an insulating resin [21] covers its surface.

13. A battery pack as recited in claim 8 wherein the surface insulating layer is formed of plastic, and the insulating substrate [9A] is attached during plastic surface insulating layer formation by insertion into the plastic.

14. A battery pack as recited in claim 8 wherein insulating substrate [9A] and the surface insulating layer [9B] of the one-package unit are the same insulating material.

15. A battery pack as recited in claim 8 wherein insulating substrate [9A] and the surface insulating layer [9B] of the one-package unit are different insulating materials.

16. A battery pack as recited in any of the claims 8 to 15 wherein a test-point hole is provided in the surface insulating layer [9B] of the one-package unit.

17. A battery pack as recited in claim 16 wherein the test-point hole is opened at a location allowing contact with a test-point of the protection circuit [3] mounted on the upper surface of the insulating substrate [9A].

18. A battery pack as recited in claim 16 wherein a removable seal or filler material closes off the test-point hole.

19. A battery pack as recited in claim 16 wherein the one-package unit has two surface electrodes which are test-points disposed on the surface electrode side, a test-point surface electrode which connects to the B+ surface electrode via a resistor is disposed near the B+ surface electrode, and a test-point surface electrode which connects to the V- surface electrode via a resistor is disposed near the B- surface electrode.

20. A battery pack as recited in any of the claims 1 to 19 wherein the insulating holder [6] is provided next to the rechargeable cell [2], the insulating holder [6] has the holding space [14] opening on the side facing the rechargeable cell [2], the one-package unit [9] is disposed in this holding space [14], and the insulating holder [6] is disposed at the end of the rechargeable cell [2].

21. A battery pack as recited in any of the claims 1 to 19 wherein the one-package unit [9] is mounted on a printed circuit board [19], lead material [10] is joined to the printed circuit board [19], and the one-package unit [9] and the printed circuit board [19] are attached to the insulating holder [6].

22. A battery pack as recited in any of the claims 1 to 21 wherein the one-package unit is rectangular shaped and has surface electrodes [B+] and [B-] disposed in the corner regions of its bottom surface.

23. A battery pack as recited in claim 8 wherein surface electrodes [B+] and [B-], which connect to the rechargeable cell [2] positive and negative sides, are disposed at the ends of opposing sides of the one-package unit [9].

24. A battery pack as recited in any of the claims 1 to 22 wherein the rechargeable cell [2] is a thin outline battery, and a lead to connect the one-package unit [9] to the rechargeable cell [2] is disposed along the side edge of the wide surface of thin outline rechargeable cell [2].

25. A battery pack as recited in any of the claims 1 to 23 wherein the rechargeable cell [2] is a thin outline battery, the one-package unit is rectangular shaped, lead material [10] is joined to the one-package unit [9] in a fashion protruding lengthwise from the ends of the rectangular shaped one-package unit [9], lead material [10] extending from the ends of the one-package unit [9] connects with projecting rechargeable cell [2] electrodes, and the rectangular shaped one-package unit [9] is disposed in the holding space [14] of the insulating holder [6] in a manner orienting the one-package unit [9] parallel to the end of the long narrow rechargeable cell [2].

FIG. 1

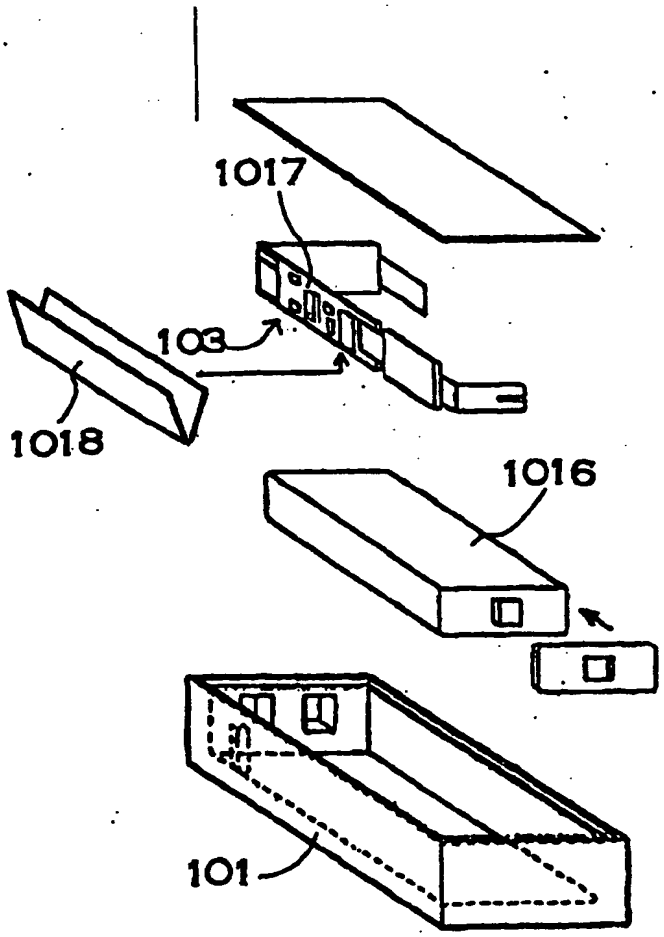

FIG. 2

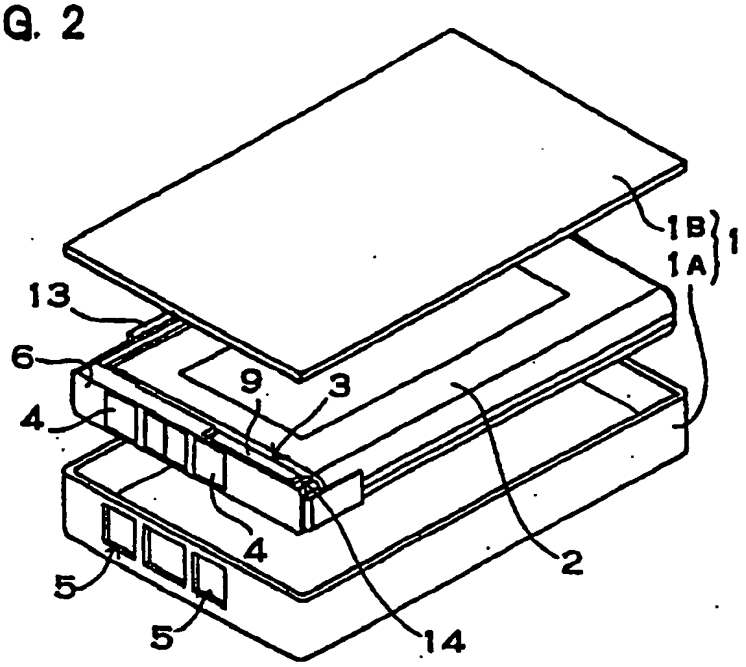

FIG. 3

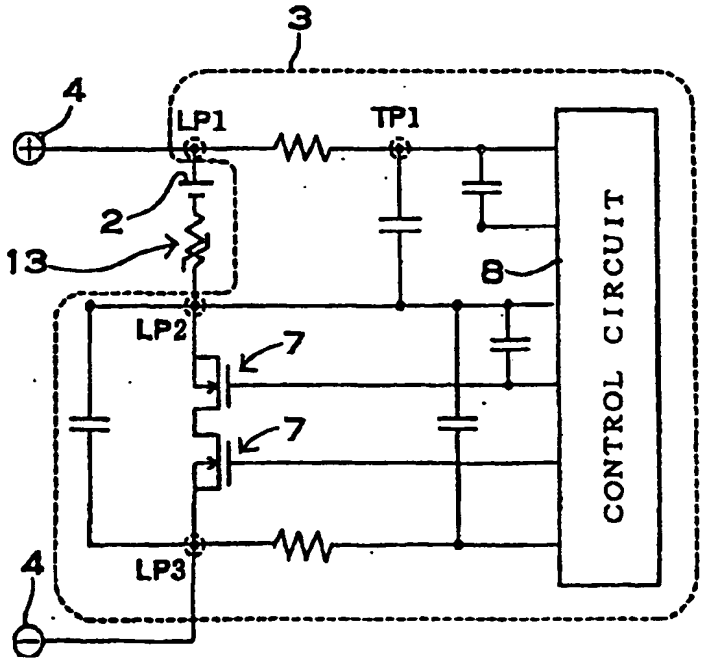

FIG. 4

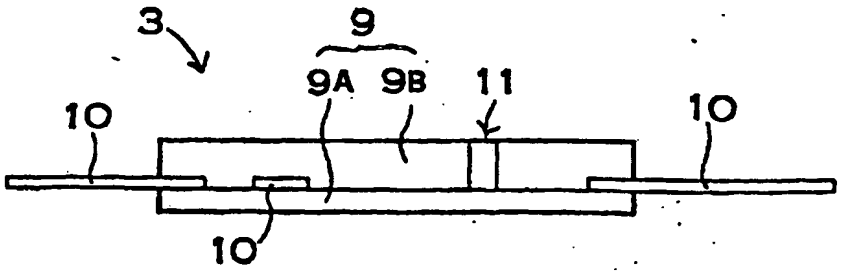

FIG. 5

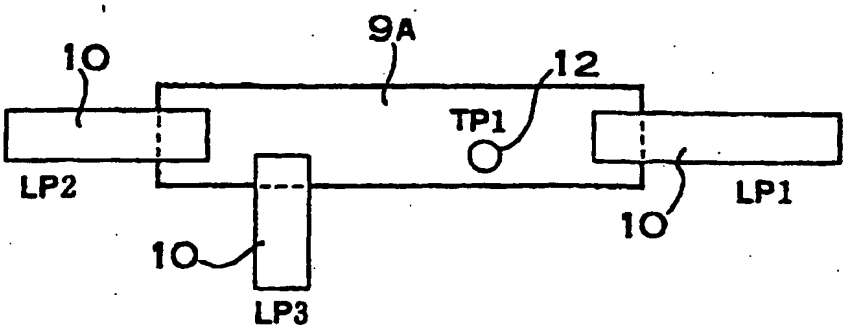

FIG. 6

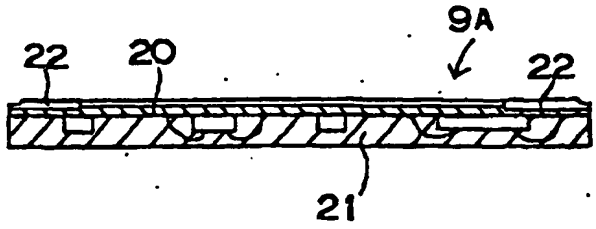

FIG. 7

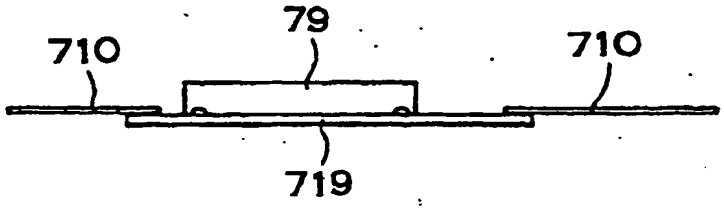

FIG. 8

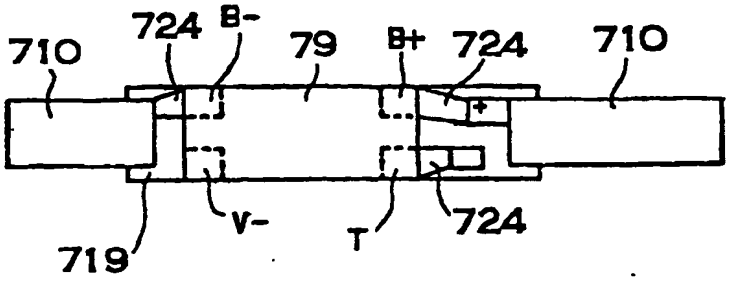

FIG. 9

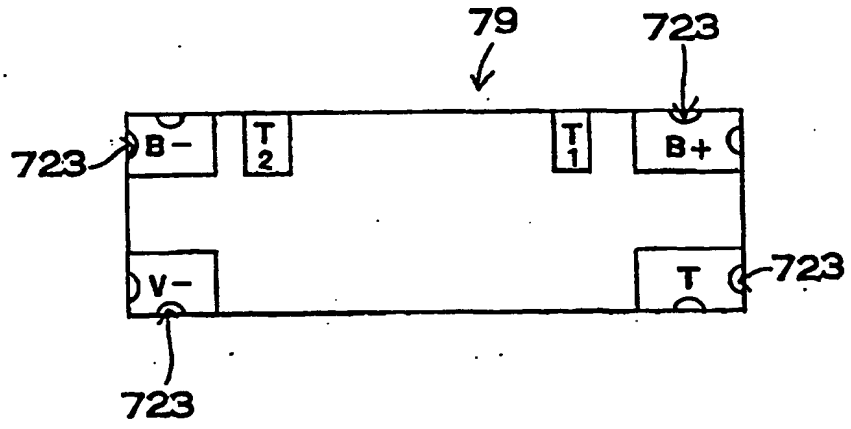

FIG. 10

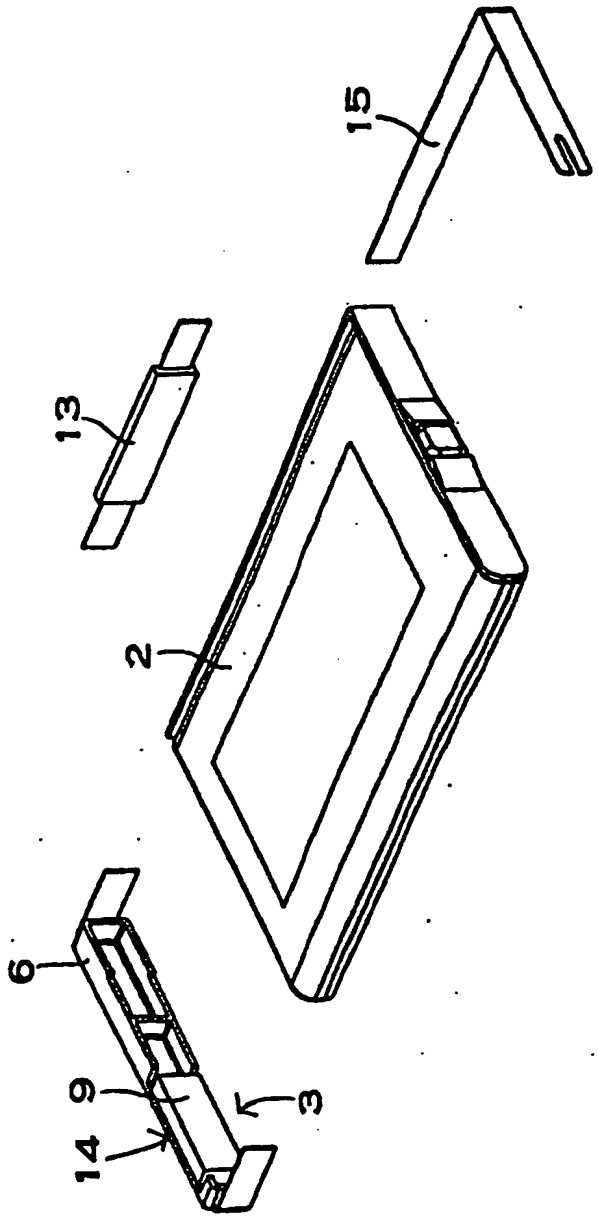

FIG. 11

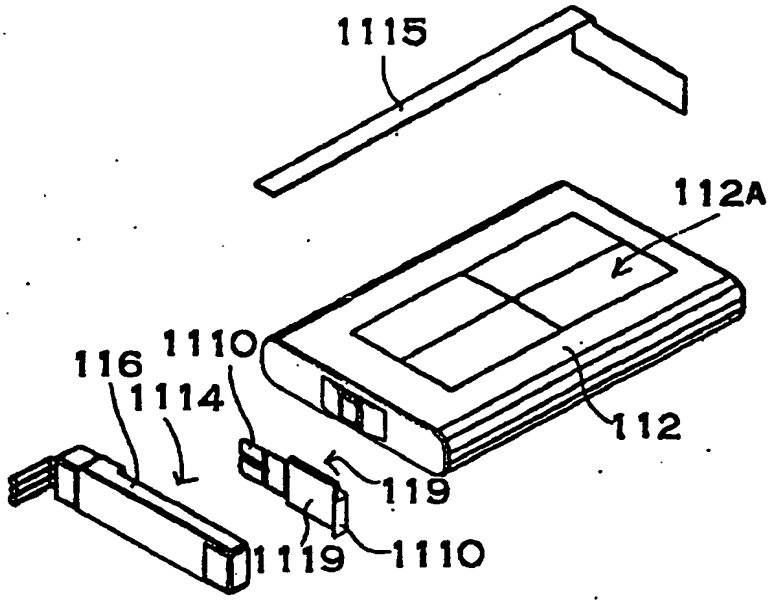

FIG. 12

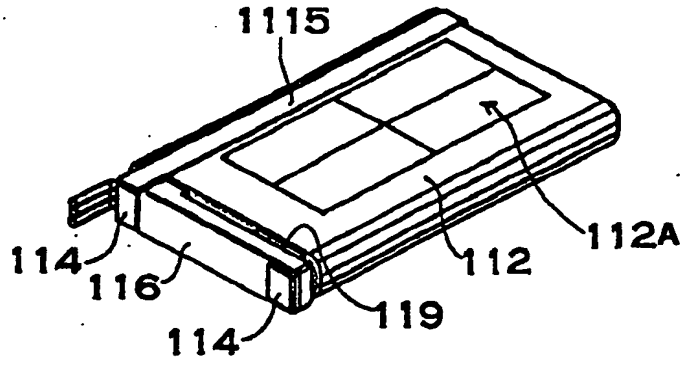

FIG. 13

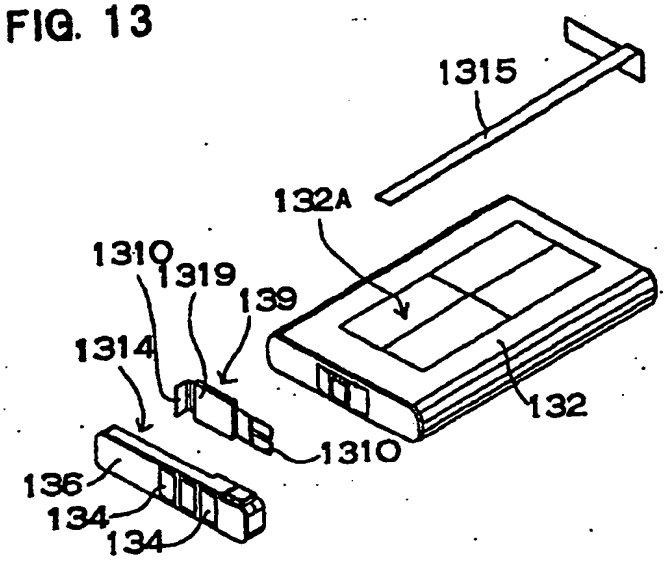

FIG. 14

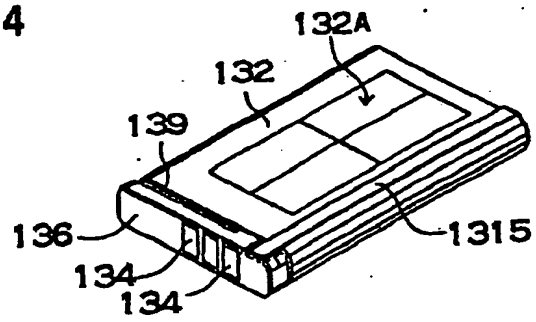

FIG. 15